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THE METALLOGRAPHY OF THE ALLOTROPIC SCHOOL.

Microscopic Analysis of Metals. By Floris Osmond, Paris. Edited by J. E. Stead, F.R.S. Pp. vii + 178. (London: C. Griffin and Co., Ltd., 1904.) Price 7*s.* 6*d.* net.

THIS book is a translation of a French edition embodying several papers published by M. Osmond between 1895 and 1900. The editor, Mr. Stead, in a somewhat florid preface, states that he has confirmed most of Osmond's assays, and claims that the book must be regarded "as a standard work on metallography." This claim will be difficult to justify, since an *ex-parte* statement of the views of the leader of the allotropic school of metallurgy can hardly constitute a standard work, in which necessarily the facts and theories of both schools of thought should be impartially set forth and enunciated. Again, the work is to some extent unsystematic, as in its early pages gold, steel, silver and bronze are mixed together in a somewhat puzzling manner, and such important alloys as white metal and brass are not dealt with at all. Most of the photomicrographs are excellent, whilst a few are very indifferent.

In his preface Mr. Stead highly eulogises the method of "polish attack" for revealing structures. There is no doubt that it is useful for developing structures in an exaggerated form, but for the identification of constituents it is a method prolific in errors. With unconscious naïveté, M. Osmond on p. 73 admits this, remarking, "It is necessary to look at the sample periodically in order to stop when the desired effect is obtained." In an acute controversy between two schools of scientific thought, a method capable of giving a "desired effect" would seem a little out of place, and a method giving the actual result more desirable.

On p. 73 it is quite evident that M. Osmond has not realised that what he calls his "chemical attack" is really an electrochemical or galvanic attack, since efficient etching is achieved owing to the fact that the various constituents assume in the electrolyte or etching liquid either the electronegative or electropositive position. The latter, or anode, constituents are attacked, whilst the former, or kathode, constituents are relatively untouched. It is necessary to direct attention to a photomicrograph on p. 53, Fig. 34. This purports to be the structure of gold containing 0.2 per cent. of bismuth. The metal appears to be pure gold, as no sign of the well-known bismuth eutectic cement is visible between the crystals; Messrs. Osmond and Stead in publishing this structure must have forgotten that the late Sir W. C. Roberts-Austen admitted that he was not sure that the sample contained any bismuth.

Turning to steel, M. Osmond remarks on p. 107:—

"My trials have been specially carried out on five samples of the purest classes of steel made industrially, containing varying amounts of carbon, other foreign elements being in small and very slightly differing proportions."

Practical steel metallurgists will be little inclined to agree with the foregoing paragraph, since on referring to the table on the same page and the information on the following pages, it will appear that No. 1 sample is Swedish wrought iron (containing the unusually high percentage of 0.25 per cent. of manganese) which has been submitted to the malleable iron process of annealing in ore, and is hence a product unknown to commerce. No. 2 sample is an extra soft open-hearth steel, containing 0.14 per cent. of carbon and only 0.19 per cent. of manganese. This steel must have been very "wild" and oxygenated. No. 3 is a commercial steel rather low in manganese. No. 4 is a crucible turning-tool steel containing no less than 0.35 per cent. of silicon, being hence abnormal and unfit for water quenching experiments. No. 5 is stated to be extra hard cemented bar; as it contains 1.57 per cent. of carbon, it cannot be correctly classed as extra hard, but may appropriately be called abnormal, as it contains about six or seven times the amount of manganese usually present. Throughout his investigations M. Osmond has ignored the important influences of manganese and silicon.

Turning to the photomicrographs of the 0.14 per cent. carbon steel, there will be found on p. 116, Fig. 56, the structure of this steel magnified 100 diameters, the crystals shown being very coarse. On p. 117, Fig. 57, is shown the same steel magnified 100 diameters after re-heating to 750° C. A most remarkable fining down of the structure appears to have taken place, and this in spite of the dictum of Mr. Stead that such fining down only takes place at about 900°. Probably a simple explanation of these misleading photomicrographs is to be found in careless editing, likely hopelessly to puzzle students. The "v × 100 diameters" should, under Fig. 56, and repeated in the text, p. 114, probably read "v × 1000 diameters." In the interests of students it would be well if the publishers inserted an erratum slip in connection with this unfortunate error.

On p. 145 it is stated in the last paragraph:—

"C. Influence of Quenching.—A rondelle was heated and quenched at 735° in water at 15°. Hardening at this temperature produces fractures."[1]

That quenching at 735° produces fracture is opposed to the accumulated experience of a century and a half. The explanation of the isolated fact upon which M. Osmond bases so sweeping a generalisation is to be found in the circumstance that his tool steel was so impure with silicon as to be almost unfit for water hardening. With reference to the foot-note (the accurate translation of which has been verified from Osmond's original memoir published in May, 1895), it is no doubt true that the procedure there advocated would tend to prevent cracking, but unfortunately it would also prevent hardening, since steel quenched after the finish of the transformations during the cooling would be quite soft, because the carbon

[1] "The whole secret of hardening without cracking appears to be in quenching before the end of the transformations (during the heating) or after their finish (during the cooling). But that is easier said than done when the eye is the only guide. Hence the necessity for specialists. Again, these specialists are often found in error, when the point to which they have been accustomed is changed. Then they declare that the new steel is bad."

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would be necessarily existing in the normal carbide condition.

Turning to the vexed question of nomenclature, the chapter on what M. Osmond calls the distinct constituent "sorbite" will hardly convince those who regard this substance as merely the first of three phases of pearlite. On p. 87 the author says, concerning sorbite:—

"Often very fine and deep lamellæ of cementite are found which are more or less continuous: this is what Fig. 45 (polish-attack v × 1500) ought to show, if the feebleness of the original photograph has been sufficiently reproduced, which is doubtful."

The reviewer does not pretend to grasp the meaning of this paragraph, unless owing to faulty translation the word feebleness has been substituted for delicacy. The following lines on p. 91 are also obscure; referring to sorbite M. Osmond says:—

"In the first edition of this work I did not give with sufficient clearness, ideas which were perhaps slightly confused."

With reference to "martensite," which M. Osmond calls "the fourth constituent," many metallurgists hold that it is a crystalline structure found in both hardened and unhardened steels, and hence cannot be a constituent.

It is stated by Mr. Stead in his preface that the special appendix on what M. Osmond calls the constituent "austenite" renders the work complete. On p. 39, Fig. 20, is figured in an excellent photomicrograph a pale substance stated to be austenite, and a dark substance which is called martensite. Carbonists, however, hold that the pale areas are hardenite containing dissolved cementite, the dark areas being a mixture of hardenite and free cementite (M. Osmond's methods are evidently not sufficiently delicate to detect in the dark so-called martensite the constituent last named). On etching, the hardenite with the free cementite assumes the anode position, but the areas of hardenite with the dissolved cementite assume the kathode position, and are hence unacted upon.

In the appendix on "austenite," a 1·55 per cent. carbon steel was evidently annealed in iron ore until the surface carbon was reduced to 0·35 per cent., the middle still remaining at 1·55 per cent. The composite mass was then quenched, polished and scratched with a needle. M. Osmond then found that the 0·37 per cent. region was harder than the 1·55 per cent. region, and hence that "austenite" is soft. No proof is given that in the high carbon region the separation of graphite had not been brought about by the annealing. However, no practical steel metallurgist can believe that a 0·37 per cent. carbon steel, rapidly quenched from 1050°, is harder than a 1·55 per cent. carbon steel quenched under the same conditions, because it has been frequently established that the latter will scratch quartz (7) and the former only apatite (5).

Concerning hardness, M. Osmond says on p. 83 that cementite has a hardness of 6 (felspar), and is harder than quenched steel. It is well known to mineralogists that the best classes of pen-knife blades (*which have been tempered*) have a hardness of 6 to 6·5, and that fully hardened steel has a hardness at least equal to that of quartz (7).

In connection with micrographic definitions it is interesting to note that within a year two books dealing with the microstructure of metals have been published by prominent members of the allotropic school, namely, the work under review and one by Prof. Howe.

It will be well here to quote the respective definitions given as to the nature of austenite.

Osmond (p. 98).—"To obtain it" (austenite) "the temperature of the steel must be above 1000° and the temperature of the quenching bath a little below, or just at, 0° C., and the proportion of carbon must exceed 1·1 per cent."

Howe, "Iron, Steel and other Alloys" (p. 179).—"Austenite, the characteristic and chief constituent of suddenly cooled, *i.e.* 'hardened' steel, is a hard, brittle mass, with a needle-like structure, and is a solid solution of carbon in iron, the proportion of carbon varying from nothing up to about two per cent."

Of allotropic definitions, students of metallography, somewhat modifying the words of Enobarbus, may well say:—

"Truth cannot wither them, nor custom stale
Their infinite variety."

Also Prof. Howe's reference to "a solid solution of carbon in iron" containing no carbon seems distinctly Hibernian.

All students should obtain M. Osmond's book. His brilliant and valuable thermal work and the charm of his ingenuous writings have made him many friends amongst those who strenuously oppose his theories and nomenclature. His book gives a fairly clear enunciation of his views, which are now accessible to all, whereas before they had been fully set forth only to those familiar with his original memoirs in French; nevertheless, a perusal of his book will reveal to many metallographists the fact that his patient work has been carried out in an environment perfectly detached from the stern actualities of the great world of practical steel metallurgy.

J. O. ARNOLD.

ZOOLOGICAL ESSAYS.

Mostly Mammals. Zoological Essays. By R. Lydekker. Pp. ix + 383; with sixteen full-page illustrations by the Duchess of Bedford, Lord Delamere, the Hon. Walter Rothschild, J. Wolf, and others. (London: Hutchinson and Co., 1903.) Price *12s. 6d.*

THOSE who already know these zoological essays will welcome their re-publication in book form; those who have not previously discovered them in periodical literature may be envied their treat in store. For the essays are at the high-water mark of zoological exposition; they are vividly interesting, yet scrupulously accurate; they are rich in fresh facts, salted with big evolutionary ideas. The author is well known as one of the foremost experts on mammals, and he has exhibited for many years the great gift of discussing difficult problems "popularly," without blunting the edge of his scientific thoroughness.

Some of the essays discuss man's influence in ex-

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